



# A Motivational 3D EdTech in Online Education: Digital Exhibition Space

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**Abstract.** With the outbreak of COVID-19, university classes in Hong Kong have had to transfer into online digital formats. Although no significant difference in learning outcomes between traditional classroom and online learning has been identified, students are still likely to feel distracted or bored. Thoughtful pedagogical strategies and learning design are needed to avoid disengagement which could have negative impact on their academic performance. Regarding the forms of student interactivity or features of online environments, this study examines a motivational EdTech tool - Digital Exhibition Space (DES) - which provides explorative learning experiences for students to foster meaningful peer socialisation. DES creates a 3D visual learning community aimed at enhancing connectivity amongst students, and relatedness between students and their learning artefacts so as to leverage student engagement and learning effectiveness in online education. A quasi-experimental pilot study was undertaken in an entry level class of 106 undergraduates from all faculties of the university. Quantitative results revealed that 1) students in DES learning context reported a higher level of engagement than non-DES context; 2) academic performance in DES groups was better in synoptic assessment than non-DES groups while equivalent in factual knowledge tests.

**Keywords:** Educational technology · Peer socialisation · Learning motivation

## 1 Introduction

It is acknowledged that social interactivity plays a key role in learner engagement and knowledge construction in online teaching and learning; online classrooms allow students to learn at anytime and anywhere at their own pace, breaking the distance between the instructor and students [1]. Emerging technologies provide access for those who cannot join face-to-face sessions and participate in collaborative activities. This is especially so in times of emergency, such as the recent COVID-19 pandemic during which campus classes in Mainland China and Hong Kong were suspended and transferred online. Common challenges faced by educators in e-learning, including: student confusion [2]; low motivation [3]; and lack of engagement [4], may become more intense due to emotional anxiety [2], and further limit or deter the expected learning experiences and objectives.

This study examined a 3D Digital Exhibition Space (DES) used as part of the class activities in a common core course at the University of Hong Kong. DES creates a visual

learning community by allowing students to share a single online space to develop and exhibit their own learning artefacts and review each other's works. The 3D technology allowed students to wander around and explore a central space and adjoining galleries to seek subject-related information. In this process, students feel relaxed and fun, and meaningful peer socialisation and peer learning are promoted. A quasi-experimental pilot study involving 106 undergraduate students in this course was undertaken. The quantitative data revealed that, even in this time of heightened anxiety, students that studied with DES appeared to have 1) a significantly higher level of engagement and 2) better performance in synoptic assessments than the control groups.

In the next session, a brief literature review of several recent socialisation or visualization technologies applied in educational settings is provided. Then, the relevant pedagogical theories and functional interfaces of the Digital Exhibition Space are demonstrated. Followed by a description of the methodology and results of the quasi-experimental pilot study. The final part discusses and concludes the pedagogical practice and research value of this study.

## 2 Literature Review

### 2.1 Prior Tech Regarding Socialisation

Past research has identified that the use of Facebook in college education was positively related to student engagement in the perspectives of psychosocial development or cognitive development [5, 6]. Similarly, a wiki including a collection of web pages served as a collective knowledge construction repository to foster effective interaction and reflection amongst students [7–9]. However, a failed experiment was reported on using wiki as an interactive activity in class that none of the students posted anything on wiki possibly out of academic pressure and lack of confidence [10].

Although some studies reported that technology had an affirmative influence on test scores and course grades in primary and secondary schools [11, 12], there was a notable divergence in linkage between technologies and academic achievements in higher education [13, 14].

Recent studies have noted that embracing the use of technology, the alignment of meaningful learning activities/strategies and objectives in online learning environments have yet to be developed [15]. Moreover, online socialisation is still in the stage of being achieved via chat fora or video calls. The use of interactive 3D models to enrich student learning experiences has not been widely explored by researchers due to the limitation of technical efficacy.

### 2.2 Prior Tech Regarding Visualization

Talking about the concept of socialisation in online learning, naturally leads to virtual learning communities [16, 17]. It was discovered that student perception of community was lower in e-learning environments compared to traditional classes [20]. Many researchers have focused on the process of establishing social networks to support collaborative knowledge construction via virtual classrooms [18, 19]. In recent years,

researchers have defined visualization in online learning contexts differently. For example, to visualize student learning trajectories for learning analytics, a circular view diagram (3-level segments) was designed on a serious game-design learning platform in order to identify and solve learning problems [21]; a tool was developed to visualize the data (e.g. used time or scores) collected from student group's participatory behaviours in a game-based assessment with the purpose of refining the activity [22]; and an add-on tool was created and implemented on Open edX [23].

Comparatively, there has been little research that focuses on the learning outcomes, trying to visualize and exhibit student project works or learning artefacts to the public as a group, to motivate and intrigue students to participate more, attempt more and contribute more in their assignments.

### 2.3 Research Rationale

The research team noted that student engagement was empirically associated with desired learning outcomes referring to their devotion of time and efforts in class activities [24]. Addressing the gaps in educational practices and research studies in higher education context, the team integrated a 3D model technique, designed and developed the Digital Exhibition Space (DES), as a motivational EdTech tool, to enhance both student engagement and academic performances by providing opportunities for explorative learning experiences and emphasizing the visualization of learning outcomes. The hypotheses proposed in this study are, that in online distance learning contexts:

H1: Students using DES will report a higher level of engagement.

H2: Students using DES will have academic performances of better quality.

## 3 Digital Exhibition Space (DES)

Underpinning the primary stance for the evolution of EdTech are meaningful peer socialisation and relatedness between students and their artefacts. Pedagogical strategies of Technology-facilitated Socialised Learning and Self-determination Theory were the framework of the design of DES.

### 3.1 Technology-Facilitated Socialised Learning

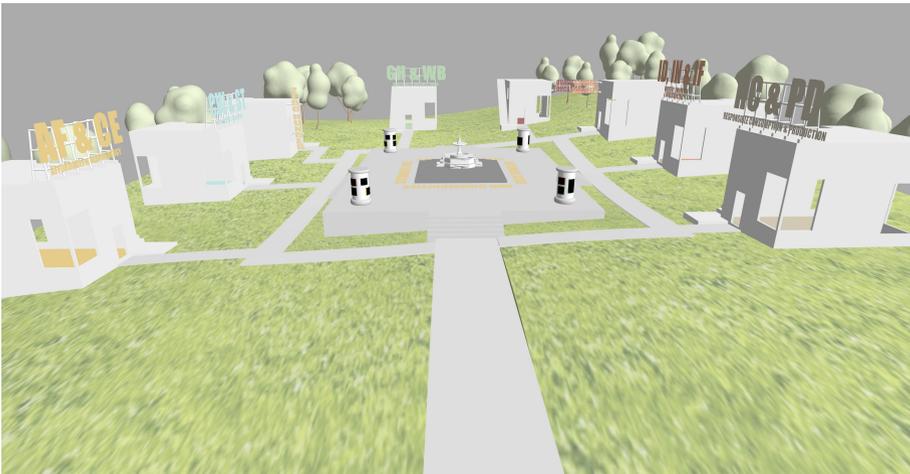
Technology-facilitated Socialised Learning (SL) is defined as a pedagogy that encourages students with different backgrounds and basic knowledge of their own discipline, to develop social connections and work collaboratively in high-tech environments [25]. Within an SL-designed course, students are tasked to exchange knowledge, regulate their own learning and group members' learning (e.g. goals, progress, quality etc.), offer help or even give some pressures to each other when needed, and critically reflect on themselves continually [25]. In essence, this framework articulates an approach to form a coherent online learning community and assign meaningful collaborative tasks for students to utilise their prior knowledge and learn from each other. By facilitating critical and reflective discourses and regulating socio-emotional interaction [26], higher levels of engagement and better learning outcomes are expected.

### 3.2 Self-determination Theory (SDT)

Relatedness, competence and autonomy were identified as three essential psychological needs in motivation [27, 28]. Relatedness stands for a sense of attachment and belonging [28]. Competence refers to the need to feel confident and effective [28]. Autonomy is having the freedom to make personal decisions [28, 29]. The former two factors underlie intrinsic motivation; and relatedness facilitates student internalization of extrinsic motivation and promotes positive outcomes in a supportive social environment [30], which are congruent with previous research findings [31]. More specifically, SDT postulates that people tend to internalize the value and regulation driven by extrinsic motivation and turn it into positive behaviours when they experience fulfilment for the needs of relatedness [30].

### 3.3 Functional Interface

Digital Exhibition Space creates a 3D environment for students to learn collaboratively within their own study groups, and subsequently with the whole class. In DES (see Fig. 1), the whole class is considered as a social learning community while individual student groups are considered as component learning units.



**Fig. 1.** Overview of 3D digital exhibition space

The format of the DES used in this course was composed of 8 galleries, each of them represents a theme relevant to the course core. Each student learning unit was assigned to a thematic gallery and relevant projects. Several units worked under the same theme but each had their own gallery space (see Fig. 2). The four columns in the central plaza delivered the learning materials and core values of the course provided by instructors.

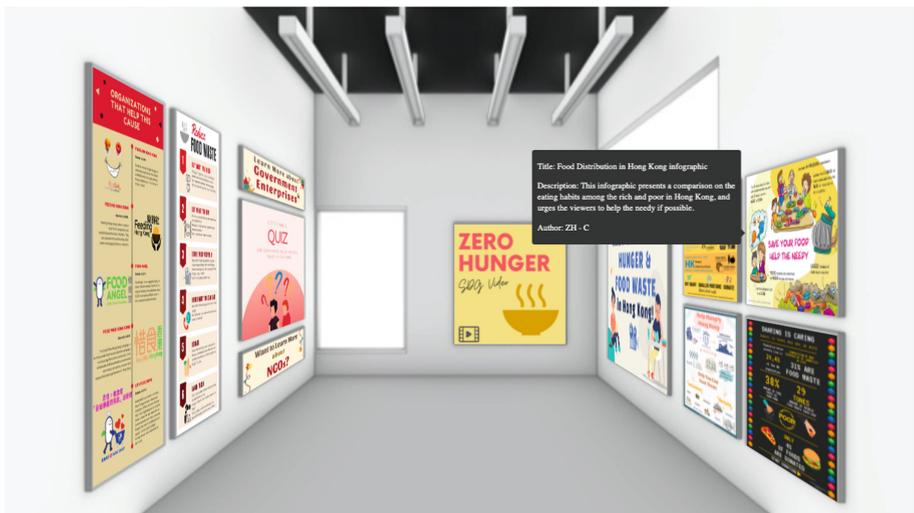
Within each thematic gallery, the frames on the walls serve as display windows for students to upload and exhibit their project artefacts. Students are required to set the



**Fig. 2.** Student learning units under each theme

cover page for the frames and populate their thematic room with a selection of their works.

Students can visit each other's room to read the title, summative description and author(s) of each frame and click the frame to view detailed contents (see Fig. 3). Access to DES and thematic rooms is open to the whole class via the Internet so that students can share their learning outcomes with anyone as an online exhibition.



**Fig. 3.** Individual thematic gallery

## 4 Quasi-experimental Pilot Study

### 4.1 Research Context

The University of Hong Kong set a series of common core courses for new undergraduates. The mission is to prepare students to become active and responsible citizens of global and local communities; develop broader and critical perspectives on complex issues; as well as understand the interconnections of these issues and their daily lives.

DES was applied in one of the common core courses which previously ran as a flipped classroom. This CC course investigates the United Nations (UN) sustainable development goals (SDG) and aims to inspire students to think about the way society might construct sustainable cities and communities in future. Students are challenged to use different media and presentational strategies in this course to develop their competence in argumentation and advocacy relating to SDGs in Hong Kong and internationally. However, classes on campus were suspended and transferred into online formats due to the outbreak of coronavirus. This led not only to a shift from a flipped class pedagogy to an online distance teaching, but also had an impact on student emotional engagement and participation.

In DES, the 8 thematic galleries respectively represented 8 different SDGs, such as Zero Hunger, Gender Equality and Quality Education etc. The plaza played the central role of Sustainable Cities and Communities, whose development was constituted and contributed by the surrounding SDGs. Each SDG had three groups of 4 or 5 students (106 students and 24 groups in total, 10 groups of 5 and 14 groups of 4) working on it. There were a set of SDG-relevant assignments that students needed to accomplish individually or with their group mates, for instance preparation of: advocacy videos; infographic diagrams; postcards; and so on. Moreover, students could decide what additional artefacts they would like to develop for their gallery, like developing a quiz or a game for visitors, making a meme, etc. During the learning process, students were constantly uploading and populating the SDG galleries with the works they had created (and were satisfied with). Since the gallery was only required to be published at the end of the course, students were allowed to not publish the frames until they felt confident. Students' work could be updated or amended at any time. Students could also visit other classmate's SDG galleries to learn from their published frames.

In this pilot study, we randomly divided 106 students into an experimental learning environment and a controlled learning environment. In the DES experimental group, there were 55 students (7 groups of 5 and 5 groups of 4) while in the non-DES controlled group, there were 51 students (3 groups of 5 and 9 groups of 4). DES was introduced to students in the experimental group from the first session, and later via online Zoom tutorials. While students in the control group only had online Zoom tutorials. The whole quasi-experimental pilot study lasted for 5 weeks and students in both learning environments had access to learning materials on Open edX. Learning materials uploaded on DES and Open edX were the same.

### 4.2 Participants and Instruments

89 undergraduates in this course gave their consent and participated in this pilot research study. A quasi-experiment was conducted and amongst participants, 51 of them were

from DES experimental groups, while 38 were from controlled groups; 48 of them were female and 41 of them were male; 74 of them were year 1 students and 15 of them were year 2. The participants were distributed across the university in 9 different faculties which were Faculty of Engineering, Medicine, Arts, Architecture, Law, Business and Economics, Dentistry, Science and Social Science.

Student engagement was measured by a 10-item self-reported questionnaire (Skinner, Kinderman and Furrer 2009), derived from Wellborn (1991), evaluating both behaviour and emotional engagement. Student academic performance was evaluated by the grade of two individual assessments: a reading response and a quiz. The reading response was based on a pre-class given SDG reading, which required a comprehensive understanding and critical mind set on the SDG as it related to personal, territorial (Hong Kong) and global scales. Students were asked to share their ideas and discuss within their groups on Zoom, and individually constructed a short argument after class. Students in the DES experimental group were asked to design a cover page and upload their reading response to their SDG gallery. The quiz was based on two pre-class course videos recorded by the instructor (the second author) testing about the factual knowledge and statistics of a SDG, and conducted in a Zoom tutorial. Marking was an anonymous process in which identifiers like student number and name were removed.

### 4.3 Data Analysis and Results

Normality test, independent sample t-test and Mann-Whitney U test were undertaken after the data collection to test whether there was a significant difference in engagement and learning performances between experimental groups and control groups.

**Engagement.** To analyze the collected questionnaire data from both experimental and control groups, the normality of student engagement data distribution was tested in SPSS. Histograms are presented (see Fig. 4 and Fig. 5) and Shapiro-Wilk test suggested a normal distribution in the data of non-DES controlled groups,  $W(38) = .959, p = .18$ ; while an insignificant normality was indicated in the data of DES experimental groups,  $W(51) = .952, p = .038$ .

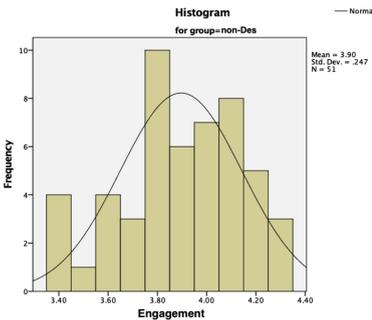


Fig. 4. Histogram\_Engagement\_non-DES

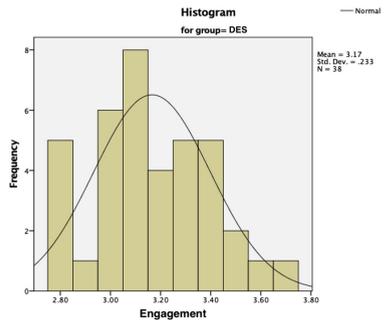


Fig. 5. Histogram\_Engagement\_DES

Thus, the non-parametric, Mann-Whitney U test, was applied to examine whether significant differences could be found between experimental and controlled groups. The

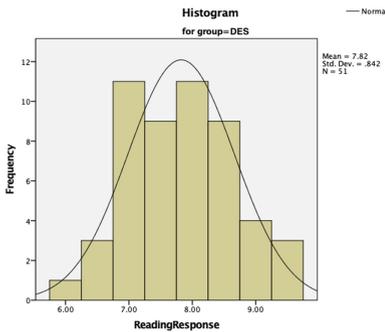
scores of self-reported engagement in DES experimental groups (Mdn = 3.9) were higher than in non-DES controlled groups (Mdn = 3.1). The results of Mann-Whitney U test supported the first hypothesis in this study, postulating that this difference was statistically significant,  $U(N_{DES} = 51, N_{non-DES} = 38) = 36.50, z = -7.76, p < .001$ . Table 1 summarizes the test results.

**Table 1.** Mann-Whitney U test results\_Engagement

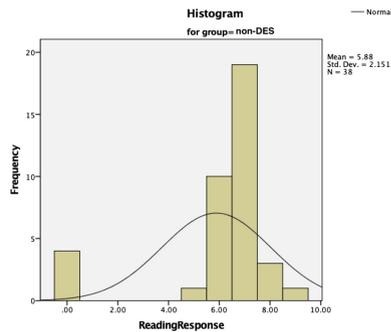
Test statistics <sup>a</sup> Engagement			
Mann-Whitney U	36.500	Wilcoxon W	777.500
Z	-7.757	Asymp. Sig. (2-tailed)	.000

<sup>a</sup>Grouping Variable: group

**Reading Response.** After collecting data from experimental and control groups, the normality of reading response scores in the two independent samples was tested in SPSS. Histograms are presented (see Fig. 6 and Fig. 7) and the Shapiro-Wilk test showed a significant normality in DES experimental groups,  $W(51) = .958, p = .066$ ; while a significant departure from normality was observed in non-DES control groups,  $W(38) = .647, p = .00$ .



**Fig. 6.** Histogram\_Response\_DES



**Fig. 7.** Histogram\_Response\_non-DES

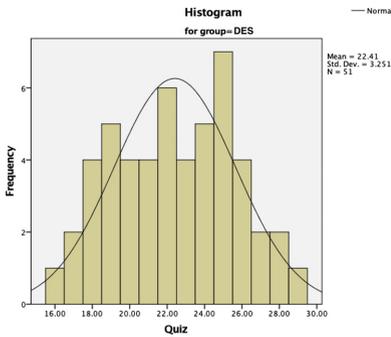
Therefore, the Mann-Whitney U test was applied to determine whether there was a profound difference in scores for the reading response between the two groups. The reading response scores of students in DES experimental groups (Mdn = 8.0) were higher than those in non-DES controlled groups (Mdn = 6.5). A Mann-Whitney U test indicated that this difference was statistically significant,  $U(N_{DES} = 51, N_{non-DES} = 38) = 222.50, z = -6.26, p < .001$ . The following Table 2 gives a summary of test results.

**Quiz.** The normality of quiz scores distribution in the two independent samples was also tested in SPSS. Histograms are presented (see Fig. 8 and Fig. 9) and the Shapiro-Wilk test showed a significant normality in both groups,  $W(51) = .973, p = .30$ , and control groups,  $W(38) = .949, p = .08$ .

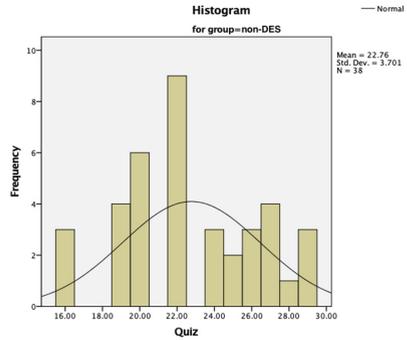
**Table 2.** Mann-Whitney U test results\_ReadingResponse

Test statistics <sup>a</sup> ReadingResponse			
Mann-Whitney U	222.500	Wilcoxon W	963.500
Z	-6.259	Asymp. Sig. (2-tailed)	.000

<sup>a</sup>Grouping Variable: group



**Fig. 8.** Histogram\_Quiz\_DES



**Fig. 9.** Histogram\_Quiz\_non-DES

Therefore, an independent sample t-test was applied. The result indicated that there was no significant difference in quiz scores,  $t(87) = -.475$  and  $p = .359$ , between the 51 students in DES experimental groups ( $M = 22.41$ ,  $SD = 3.25$ ) and the 38 students in non-DES controlled groups ( $M = 22.76$ ,  $SD = 3.70$ ). The following Table 3 and Table 4 give a summary of the test results.

**Table 3.** Descriptive data of quiz scores in experimental groups and controlled groups

	Group	N	Mean	Std. Deviation	Std. Error Mean
Quiz	DES	51	22.412	3.251	.455
	non-DES	38	22.763	3.701	.600

Hence, the second hypothesis was only partially supported, indicating that the enhancement of learning outcomes with DES is subject to the nature of the knowledge and assessments.

## 5 Discussion and Conclusion

Researcher has mentioned that online education relies on the creation of learning communities [32]. A sense of community is based upon common goals and needs [26]. DES

**Table 4.** Independent t-test results on quiz scores in DES groups and non-DES groups

		Levene's test for equality of variances				t-test for equality of means				
		F	Sig.	t	df	Sig. (2-tailed)	MD <sup>a</sup>	SED <sup>b</sup>	95% confidence interval of the difference	
									Lower	Upper
Quiz	Equal variances assumed	0.849	0.359	-0.475	87	0.636	-0.351	0.739	-1.821	1.118
	Equal variances not assumed			-0.466	73.73	0.642	-0.351	0.753	-1.853	1.15

Notes: <sup>a</sup>Mean difference, <sup>b</sup>Std. Error difference

creates an online version of a socialised learning community for the whole class and small learning units for individual student groups. The space structure of connecting the central plaza with SDG galleries shapes the concept that building sustainable cities and communities as a core target in global villages needs to be equally constituted and contributed by different sustainable development goals, which strongly aligns with the learning objectives of the course.

Integrating the 3D model platform, DES provides students with an explorative learning experience via central plaza and SDG galleries as well as transforms students' individual and group artefacts for further peer learning. Through the activity of populating their own SDG gallery and visiting classmate's SDG galleries, students' perspectives towards the sustainability issue have been expanded and diversified; and their way of thinking about the synergy between global issues and themselves has been inspired.

Therefore, even in this challenging time when everybody is anxious, as the pilot study revealed, both student behavioural and emotional engagement in DES learning groups and scores of reading responses were notably higher than the non-DES learning groups. Since knowledge exchange, regulation of learning behaviours and reflections through meaningful peer socialisation were efficient as expected in DES, effective learning behaviours were performed. What is more, visualization and exhibition of selected project works, as well as given autonomy on personalized assignments, foster the students' ownership of their artefacts, which strengthens the sense of relatedness between themselves and their outcomes compared to the usual oblivion after submitting the works. As a result, students feel more ambitious and confident, and more willing to spend time on, and make more contributions to, their projects. Another possible clue could be the novelty of the 3D technology, which raises student curiosity to explore the unknown.

However, the student quiz scores were broadly equivalent between DES and non-DES learning groups. The results indicate that online learning innovation has limited effects

on acquisition of factual knowledge, which aligns with the previous research findings that peer socialisation is of less importance if the learning activity is about information acquisition [33]. Synoptic assessment which requires comprehensive understanding and critical mind set on a subject will benefit more from meaningful social interaction.

In conclusion, this study introduces the Digital Exhibition Space (DES) as a new motivational tool to provide students with explorative learning experience through 3D technology and helps to visualize student learning outcomes. Both student socio-cognitive and academic engagement are enhanced due to the increased meaningful socialisation amongst students and intrinsic motivations intrigued by relatedness between students and their artefacts. DES is designed to apply in both blended learning or online learning contexts. The pilot study revealed that, under the circumstances which required all classes to be conducted online, DES managed to help students achieve a higher level of engagement and better academic performance.

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